National Estuarine Research Reserve
Graduate Research Fellows
2002

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Reserve: ACE Basin, SC
Fellow: Susanne Hauswaldt
Project title: Use of diamondback terrapins, *Malaclemys terrapin*, as biological indicators for chemical pollution of South Carolina estuaries

Abstract:

Estuarine ecosystems are under unrelenting stress caused by growing development near estuaries or in estuarine watersheds. Many estuaries show an increase in contaminant concentration resulting from non-point source pollution. In South Carolina, these toxicants consist of organic contaminants, e.g. polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides, as well as heavy metals. Bioaccumulation of such persistent xenobiotic compounds in the food chain results in higher contaminant levels in organisms compared to those in the water or sediment. Exposure to chemical pollutants can result in genotoxic effects (i.e. DNA breakage), endocrine disruption, and reduced reproductive fitness. I propose to evaluate the use of the Diamondback terrapin (*Malaclemys terrapin*), an estuarine turtle, as an indicator of chemical pollution in South Carolina estuaries. Certain life-history traits of this species should make it a good candidate as a bioindicator: terrapins have great site fidelity, they feed on invertebrates that are known to accumulate toxicants, and they are long-lived. Terrapins will be sampled from two estuaries that are considered levels of toxic chemicals. Tissue burden of organic and heavy metal pollutants will be assessed in adults and eggs. Biological effects of pollutants will be investigated by comparing the amount of DNA breakage, the degree of feminization of male terrapins, and the hatching success among terrapins from the four sites. The availability and integration of such information into management plans of estuaries will ensure these habitats are safe for humans and the organisms that share them with us.

Reserve: ACE Basin, SC
Fellow: Matthew Jenny
Project title: Identification of early warning indicators of environmental stress in the ACE Basin using gene expression profiles from oysters, *Crassostrea virginica*

Abstract:

Long-term chronic exposures to metals and organic pollutants from point and non-point sources (ie. aerial deposition, boating activities) threaten estuarine ecosystems, including the ACE Basin, South Carolina. *Crassostrea virginica*, a common species found along the Gulf of Mexico and Atlantic seaboard, is an important indicator species of estuarine health and a potentially valuable model for evaluating the relationship between ecosystems and human activities. A functional genomics approach will test the hypothesis that the physiological status of oysters is reflected in specific patterns of gene expression which manifest via the interplay of internal processes in organisms and external environmental stressors. "Transcript profiling" will be used to assess and compare the expression of ~500 genes, including a family of metallothionein isoforms, in oysters from sites located primarily in the ACE Basin and a small number of highly contaminated sites in Charleston Harbor (Charleston, SC). In addition to the gene expression profiles, additional indicators of cell damage (glutathione, lipid peroxidation, lysosomal destabilization), tissue metals analysis, and environmental parameters (water and sediment quality) will be assessed. Artificial neural network techniques (ANN) will be used to analyze this multi-parametric dataset. With the ability to store and utilize experience-based knowledge, ANNs can extract ‘signal' from ‘noise' making them ideally suited for large-scale ecological monitoring. The functional genomics approach will validate and expand traditional ecological models by incorporating gene expression patterns as part of the assessment strategy. Gene microarrays are sensitive, rapid-screening techniques capable of advancing current environmental assessment tools. The success of future conservation and management practices relies on a greater understanding of the effects of environmental pressures on organismal health. Gene expression profiles will be used to identify potential early warning indicators of long-term chronic stress.

Reserve: Apalachicola Bay, FL
Fellow: Carl Childs
Project title: A spatial and temporal assessment of factors affecting denitrification in Apalachicola Bay
Abstract:

The Apalachicola Bay is a highly productive estuarine system. This high productivity is driven in large part by the input of river born nutrients. Understanding how various parameters interact to affect nutrient cycling in the estuary is a question bearing on many academic and management issues. I propose to assess the factors that regulate denitrification in the Apalachicola Bay system. Denitrification is the stepwise reduction of nitrate to the gaseous species dinitrogen oxide and dinitrogen. This reduction is the primary sink for bioavailable nitrogen species.

Station sites will be selected representing a broad cross section of the bay. These sites will be sampled on a monthly basis two annual cycles. Data will be collected on a large number of the possible controlling factors for denitrification. Nitrate and nitrite will be assayed by chemiluminescence. Chlorophyll content will be assayed by fluorometric determination. Denitrification potential will be determined by the acetylene block method. Bacterial nucleic acids will be extracted and assayed for key genes in the denitrification process. Additionally, salinity, dissolved oxygen, and temperature will be monitored.

The resulting data set will be examined for correlating between the observed rate of denitrification and the other parameters. This research will provide valuable insight into the nutrient dynamics of this commercially and economically valuable estuary. Additionally, this effort will provide a wealth of other baseline data for this estuary.

Reserve: Apalachicola Bay, FL
Fellow: Jennifer Putland
Project Title: Planktonic food web variations related to salinity and nutrient patterns in Apalachicola Bay
Abstract:

Proposed reallocation of Apalachicola river water associated with future increased upstream freshwater demands may significantly reduce the productivity of Apalachicola Bay. Defining food web structure within the bay is imperative to determining potential effects of reduced river flow. The objective of the proposed research is to test the hypothesis that a diatom-based food web predominates in phophorus-limited waters where nitrogen is sufficient for phytoplankton growth, and that a pico- and nanophytoplankton based food web exists in nitrogen-limited bay waters. Standard sampling protocols for phytoplankton, micro- and mesozooplankton will be employed. Primary productivity and nutrient enrichment studies will follow the methods of Fulmer (1997) and Mortazavi et. al. (2001). Micro- and mesozooplankton grazing assays will be conducted using the dilution (Landry and Hasset 1982) and incubation methods (Dagg 1993: Landry et al. 1993), respectively. Because the spatial areas over which phosphorus-limited and nitrogen-limited productivity varied seasonally in Apalachicola Bay in a past investigation, this information will prove useful in assessing the effects of changes in water allocation to Apalachicola Bay from Apalachicola River. The proposed research is of nationally significant interest as it addresses the mechanisms for sustaining resources within estuarine ecosystems.

Reserve: Chesapeake Bay, MD
Fellow: Jude Apple
Project Title: Linking anthropogenic nutrient inputs to microbially mediated nutrient cycling in coastal ecosystems
Abstract:

Anthropogenic nutrient loading and subsequent eutrophication of coastal ecosystems has traditionally been assessed in terms of increases in algal stock and primary production. This approach overlooks the dynamic response of microbial metabolism to nutrient loading and the subsequent effect of microbial metabolism on nutrient cycling and overall secondary production. Preliminary results from large-scale comparative studies conducted in a number of mid-Atlantic coastal systems provide evidence that there is an important link between anthropogenic phosphorus loading, microbial metabolism, and the role of bacteria in nitrogen cycling. This proposal will focus on bacterial growth efficiency (BGE), which is a parameter that combines the two main components of bacterial metabolism: production and respiration. BGE has been linked to nutrient and organic carbon availability. The proposed study will use the reserve site at Monie Bay as a model coastal ecosystem to 1) investigate the effect of anthropogenic inputs of phosphorus on BGE, 2) establish the link between BGE and microbially mediated nitrogen dynamics, particularly of dissolved organic nitrogen and urea, and 3) assess BGE as an index of nutrient loading and coastal eutrophication. The proposed study will investigate in detail the spatial, seasonal, and temporal variability at Monie Bay that may exist in the trends of BGE and nutrient cycling observed previously across larger systems. Sampling at Monie Bay will be monthly or biweekly over a three year period and will be supplemented by meso and microcosm experiments in year three. Bacterial production (BP), bacterial respiration (BR) and growth efficiency will be determined, together with ambient concentrations of organic and inorganic nitrogen and phosphorus and the microbially mediated changes in several nitrogen pools, including urea. Establishing the link between anthropogenic nutrient loading, microbial metabolism, and nutrient cycling has important implications with respect to our understanding of the function of coastal ecosystems and the management of these systems.

Reserve: Chesapeake Bay, VA
Fellow: Scott Lerberg
Project Title: Benthic secondary production in tidal marsh habitats - between and within marsh variability along a salinity gradient in the York River subestuary
Abstract:

Tidal marsh environments are characterized by their high rate of primary productivity. The trophic links between primary producers and higher level secondary consumers (i.e. fish and crustaceans) are clearly important in ecological functioning of marshes and estuaries. Although a portion of the primary production may be used directly by higher trophic groups, it is been suggested that benthic invertebrates, especially the macrofaunal and epifaunal communities, are the major trophic connection between primary producers and fisheries species within these systems. Few studies; however, have attempted to describe and more importantly quantify the levels of secondary production of this major trophic group within a particular tidal marsh system or between tidal marsh systems along the estuarine salinity gradient. This project seeks to quantify macrofaunal abundance, biomass, and secondary production within and between four tidal marsh systems (Goodwin Islands, Catlett Islands, Taskinas Creek, and Sweet Hall Marsh) which are part of the Chesapeake Bay Reserve on the York River, Virginia. This project will also examine four tidal marsh habitats on a gradient from the high marsh surface to the subtidal creek within each marsh site. Macrofauna will be quantified with a 7.6 cm diameter core sampler and epifauna will be quantified using a 0.8 m high portable drop trap enclosing an area of 0.5m2.

Secondary production by macrofaunal organisms may be the major pathway by which energy (organic carbon) is stored and recycled out of the sediment and possibly out of the system (through predation by migratory fishes and harvest). Accurate knowledge of the productivity within this trophic group will allow fisheries scientists to more accurately predict estuarine and coastal fisheries production values. Changes in macrofaunal community biomass or secondary productivity may also serve as a reliable indicator of the effects of environmental degradation and habitat alterations. The results of this study address local and regional NERRS program objectives which include: (1) the collection of community and population level information on an ecologically important group of taxa (benthic invertebrates) within and between CBNERRS marsh reserve sites; (2) developing a potential metric (benthic secondary production) for assessing marsh ecosystem restoration efforts; and (3) providing land-use managers and fisheries scientists with critical information on tidal marsh habitat value and how tidal marshes support and sustain living resources.

Reserve: Delaware
Fellow: Alex Parker
Project Title: Stable isotope tagging to assess the importance of the microbial loop in the Delaware estuary
Abstract:

The importance of heterotrophic bacteria to pelagic food webs is thought to rival phytoplankton in some marine environments. In these regions, bacterial carbon demand is met by dissolved organic matter (DOM), a pool of organic material that was thought to be largely inaccessible to higher trophic levels. DOM is released to the water through phytoplankton death, sloppy feeding by zooplankton, excretion, and exudation of DOM directly by phytoplankton. The processes that control both the rate of DOM production through phytoplankton exudation as well as bacterial utilization of DOM are poorly understood. The estuarine environment offers several interesting conditions which may play roles in controlling these processes including nutrient and DOM input and light limitation. Incubating water samples with trace additions of stable isotopes allows for the quantification of cycling rates of nutrients through phytoplankton and bacteria. From these experiments, the relative importance of direct DOM loss by phytoplankton as a source for bacterial production can be gained.

Reserve: Delaware
Fellow: Bartholomew Wilson
Project Title: Late Holocene evolution of the St. Jones Estuary in the Delaware Reserve: Implications for sustaining resources in response to anthropogenic impact
Abstract:

This project proposes an interdisciplinary study of the near-surface sediments of the St. Jones Estuary within the Delaware Reserve to determine the pre-anthropogenic environments of the estuary and adjacent watershed. The resulting data will serve as a baseline against which anthropogenic impacts on the region can be compared. The data will also provide information on the possible future environmental setting of the estuary in response to currently rising sea-level conditions.

In this project, high-resolution geophysical profiles including marine seismic (CHIRP sonar) and on-land ground penetrating radar (GPR) data will be collected to image the near-surface stratigraphy within the DNERR. Based on the geophysical profiles, vibra- and Dutch (auger) cores at selected sites will be obtained to ground-truth the CHIRP and GPR data and to determine changes in lithology (sediment type), microfossil assemblages, especially foraminifera (shelled protists), and pollen. Changes in microfossil assemblages through time will be used to determine the response of the estuary to natural changes in climate, sea-level fluctuations, and sedimentation over the past approximately 500 years, and to nutrient-loading and input of heavy metals after the beginning of settlement and extensive clearing. Changes in pollen will be used to mark the onset of settlement and deforestation, while the frequency of deformed tests (shells) of foraminifera will be used to monitor the input of heavy metals.

This study addresses the general topic of mechanisms for sustaining resources within estuarine ecosystems. In order to assess ways by which resources can be sustained, it is essential to have information on the natural, long-term environmental/geologic setting of an estuary. With this data, stressors due to anthropogenic impact can be compared to the "natural" setting. Past environments also provide important constraints on future conditions of an estuary. For example, the response of an estuary to currently rising sea-level conditions can be modeled from past transgressive sequences preserved in the subsurface sediments. This background information is essential in formulating management decisions pertaining to the future of an estuarine ecosystem.

Reserve: Elkhorn Slough, CA
Fellow: Kimberly Heiman
Project Title: The effects of the invasive reef-building polychaete, *Ficopomatus enigmaticus*, on the physical environment and biological community of Elkhorn Slough, CA
Abstract:

The number of non-indigenous species in harbors and estuaries is increasing worldwide. Some of these species produce new types of habitat not present in these environments prior to their arrival. This project looks at the effects of the invasive reef building polychaete, *Ficopomatus enigmaticus*, on the physical environment and the biological communities of Elkhorn Slough National Estuarine Research Reserve. *Ficopomatus* reefs are a highly complex hard substrate, representing a new habitat for the slough.

This project will address the physical changes to the hydrology and sediment due to the presence of *Ficopomatus* reefs. Sedimentation rate, sediment characteristic, and flow velocities will be characterized within and around reef and at control sites lacking *Ficopomatus* reefs.

Variation in benthic community composition in and around reefs will be examined by comparison with control sites lacking reefs and biogenic habitats formed by native oysters. Transplant experiments will be conducted to determine how the establishment of *Ficopomatu*s changes the preexisting community composition and to see if this change is attributable to the living organisms or some aspect of the physical structure of the reefs. Removal experiments will be conducted to monitor the recovery of benthic communities after removal of established reefs. Finally, rates of expansion of established reefs will be monitored through photographic sampling of reefs. Recommendations for control of *Ficopomatus* based on the outcome of these experiments will be provided.

Reserve: Elkhorn Slough, CA
Fellow: Sherry Palacios
Project Title: Seagrass restoration by carbon dioxide enrichment: Improving habitat quality for submerged aquatic vegetation
Abstract:

Seagrasses are among the most productive plant communities worldwide and are a critical part of coastal and estuarine ecosystems. Yet in the past 100 years, the world's seagrass distribution has significantly declined due to increased turbidity through non-point source pollution, dredging, eutrophication, and other means causing a decline in seagrass distribution throughout our nation's estuarine reserves and worldwide. The purpose of this research project is to develop technologies to expand seagrass distribution in the turbid coastal estuarine environment in advance of the cleanup of the watershed. The two objectives of this study are (1) to determine if CO_2 enrichment decreases light requirements sufficiently to increase the potential depth range of eelgrass and (2) to determine if industrial flue gas can be used to expand eelgrass depth distribution in turbid coastal estuarine environments. This project will exploit both controlled, contained systems and a field experiment. Tanks plumbed with running seawater and exposed to natural sunlight intensities of 100%, 10%, 5%, and 1% scalar irradiance (Eo) will be exposed to a range of CO_2 treatments for 60-90 days. Growth rates and metabolic activity will be evaluated to predict eelgrass light requirements at CO_2 enrichment. To test the second objective, 10% CO_2 flue gas, scrubbed of CO, will be used to enrich experimental treatments of eelgrass (as in the first experiment). Following the contained treatment experiment, field sites will be plumbed with CO scrubbed flue gases over a depth range that exceeds the present depth range of the seagrasses (0.3m mean low low water). Eelgrass will be transplanted to these greater depths at both the treatment (enriched) and control sites. Growth, survival, and carbon balance will be monitored to determine if this method of enrichment promotes eelgrass growth in turbid water, as our model predicts, without increasing algal growth or decreasing infaunal survival. The significance of the proposed research is that it promises to demonstrate the utility of an industrial waste product to increase seagrass productivity and depth distribution. This project provides the opportunity to partner industry with environmental managers in the restoration and protection of our coastal wetlands.

Reserve: Grand Bay, MS
Fellow: Donna Drury
Project Title: Effects of invertebrate grazer density manipulations on wigeongrass, *Ruppia maritima*, exposed to nutrient enrichment
Abstract:

This study is designed to assess the effect of grazing grass shrimp on the productivity of submerged vegetation (SAV) in estuarine ecosystems. This research can contribute to the understanding of mechanisms for sustaining resources within estuarine ecosystems by providing data for models of estuarine processes, and by elucidating processes that affect the health of estuarine SAV. This study will also examine the effect of eutrophication in estuarine ecosystems by assessing the ability of shrimp grazers to control epiphytic algal growth in SAV subjected to nutrient loading. The purpose of this study is to determine how the grass shrimp, *Palaemonetes sp.*, might affect the productivity of *Ruppia maritima*, by removing epiphytes and epifauna under increased nutrient conditions. Differences in grazer density and subsequent grazing intensity on R. maritima growth and epiphyte biomass and community composition under ambient and nutrient enriched conditions will be investigated.

The study approach will entail manipulative field experiments. Plexiglass cylinder enclosures (n=36, 0.91 m high, 14.6 cm diameter) will be deployed with marked pre-measured (weight and length) grass shrimp at three levels of grazing [low (0), medium (3), high (10)], and unenclosed control areas will be monitored within each of three *Ruppia maritima* sites in Middle Bay in the Grand Bay Reserve. Nutrients will be added to half of the cylinders and cylinder water nutrients will be analyzed weekly for N and P. The experiment will be deployed in Fall 2002 and run for 28 days. After 28 days, *R. maritima* samples will be removed with the cylinders; wet weight of shoots and epiphytes, shoot and root biomass (dry weight and ash weight), and length and biomass change in grass shrimp will be determined. High performance liquid chromatography will be conducted on epiphytes to analyze grazer effects on community composition and quantity. A split-split plot design will be used to analyze the data. By considering trophic responses across a range of grazing levels and under different nutrient loading conditions, the ability of invertebrate grazers to control epiphytes on *R. maritima* under enhanced nutrient conditions can be elucidated.

Reserve: Grand Bay, MS
Fellow: Guillermo Sanchez
Project Title: Habitat mapping of oyster resources and submerged vegetation for the Grand Bay NERR, Mississippi
Abstract:

The Grand Bay NERR contains a number of coastal wetland habitats including estuarine tidal marsh, shallow water open bay, wet pine savannah, submerged grassbeds, oyster reefs, and coastal swamp. Grassbeds and oyster reefs provide structurally complex habitats for a variety of organisms and are sensitive to changes in water quality and sedimentation. Potential for anthropogenic-induced change in the GBNERR habitats is heightened by the proximity of the reserve to the heavily industrialized Mobile Bay and Pascagoula estuaries. Precise location and extent of coverage of these two important bottom communities will serve to provide necessary information that can be used to monitor future changes in the GBNERR ecosystem. The distribution of oyster reefs and submerged vegetation will be described from vertical aerial photography. Multispectral analysis will be performed with a combination of black and white, color and infrared imagery. Photographic information will be complemented with field surveys (visual observation, boat-mounted side scan sonar, and manual poling of oyster areas) and with published scientific information. Field survey data and interpretation of aerial photographs will be used to produce high resolution, precise maps of these important habitats.

Reserve: Great Bay, NH
Fellow: Catherine Bozek
Project Title: The effects of seawalls and berms on salt marshes: Implications for marsh persistence and restoration of self-maintenance
Abstract:

The purpose of this study is to examine the effects of man-made barriers, such as seawalls and berms, on salt marshes in the Great Bay Estuary of New Hampshire. Effects on sedimentary processes due to wave reflection off of the structure will be examined by using marker horizons and grain size analysis. The influence of seawalls and berms on wrack cover will also be assessed. Well transects will be installed to determine if seawalls and berms have an effect on fresh groundwater inflow to the marsh. The impacts of wave reflection, wrack burial, and groundwater flows on salt marsh vegetation will be assessed by studying the plant populations along transects in areas with and without man-made structures. The process level results examined at specific sites will be interpreted in the larger context of the distribution of barriers in the Great Bay Estuary, NH, and implications for the future persistence of salt marshes adjacent to these structures will be assessed. Biodegradable wave buffers may help to lessen wave energy and decrease erosion due to wave reflection. Buffers will be installed at selected sites and the success of vegetation transplanted to the area will be assessed.

This project is significant on many levels. First, a basic understanding of the processes occurring in marshes near seawalls and berms is needed. The effects of these processes on natural salt marsh plant diversity can then be determined. these effects can be applied to marshes within the Great Bay Reserve, as well as marshes throughout the Great Bay Estuary and potentially to all salt marshes in New England. Understanding the effects of seawalls and berms on salt marshes will help managers guide regulation of these structures in the future.

Reserve: Great Bay, NH
Fellow: Aaren Freeman
Project Title: The ecological significance of phenotypic plasticity in blue mussels, *Mytilus edulis*
Abstract:

Understanding the mechanisms that influence growth and survival of prominent intertidal and shallow subtidal organisms is essential to the holistic management of coastal systems and for predicting the impacts of anthropogenic changes to these systems. *Mytilus edulis* is a common mussel within estuarine and near shore marine systems, and plays an important role in structuring these communities by providing habitat and a foundation of the benthic food chain. Survival and growth of *Mytilus* are mediated by characteristics, such as size, shell thickness, and strength of attachment to substrate, that have all shown variable development resulting from exposure to predators. Research proposed in this study will use multi-factorial laboratory and field experiments to address the following questions: 1) Does the degree of character induction correlate with the time since introduction (for *H. sanguineus* and *Carcinus maenas*) or the strength of the species interactions? 2) How do environmental factors such as eutrophication and salinity influence the expression of inducible defenses in *Mytilus*? 3) Do induced and uninduced mussels exhibit different mortality rates due to factors such as predation and wave dislodgement? 4) Do characters induced by one predator protect *Mytilus* from another predator with a different attack strategy? Together these results will provide a better understanding of the factors affecting the expression of inducible characters, how anthropogenic disturbances might impact the phenotypic responses of mussels, and how the expression of these inducible characters may influence the survival of mussels and the communities they occupy.

Reserve: Guana Tolomato Matanzas, FL
Fellow: John Baker
Project Title: The effect of salt spray, freshwater supply and forest seed source on ecological succession on dredge spoil islands along the intracoastal waterway in northeastern Florida
Abstract:

In this study, the effect of salt spray, freshwater supply and forest seed source on ecological succession on different aged dredge spoil islands along the intracoastal waterway in Northeastern Florida will be determined. The study will provide basic knowledge about spoil island habitat, evaluate the presence of patterns in the primary succession of maritime forests and spoil islands, provide information on the ability of spoil islands to support tree growth and provide information on how size, shape and location of spoil islands determine specific vegetation patterns. The study will contribute to developing methods for estuarine ecosystem restoration and provide information on mechanisms for sustaining resources. It will help determine how quickly maritime forest can be restored through primary succession and natural seed dispersal mechanisms given certain environmental and spatial variables. Soil characteristics measurements will include organic matter content, soil moisture and soil particle size. The Point-Centered Quarter Method and the Braun-Blanquet Scale will be used to measure abundance and cover for plant species on randomly located east-west transects. Soil moisture and relative elevation will be estimated at each vegetation sampling point. Soil cores for percent organic matter determination and salt spray will be sampled on one-east-west transect for each spoil island. Maritime forest tree seeds and seedlings will be planted in different vegetation zones. Tree growth and survivorship will be measured. Maritime forest habitat adjacent to spoil islands will also be sampled in a similar manner as the spoil islands. Multiple regression statistics will be used to interpret the data.

Reserve: Guana Tolomato Matanzas, FL
Fellow: Ashley Murphy
Project Title: Describing human uses, evaluating existing management and delineating ecological resources, the formulation of an estuarine planning strategy: A case study of the GTM NERR

Abstract:

The research proposed in this project seeks to combine the best of land use zoning and protection strategies to create an estuary plan that identifies areas for natural resource protection, while enhancing water-dependent uses. This research will develop a scientifically defensible method for creating estuarine zones based on resource presence and human use patterns, integrating the ecological, sociological, and political components of a coastal area to create zones of marine use and space.

Estuary planning in particular is needed in the GTM NERR as this coastal area is under development pressure. The results of this research will contribute to coastal and marine resource management through the development of a methodology for inventorying important coastal and estuarine resources, subsequently leading to a better understanding of how humans interact with the coastal and marine environment. The process of estuary planning will reveal mechanisms for sustaining resources within estuarine ecosystems through the integration of environmental science, sociology, and management analysis. In addition, it will highlight major human uses of an estuary making it applicable to the socioeconomic aspects of estuarine ecosystem management.

Reserve: Hudson River, NY
Fellow: Catherine McGlynn
Project Title: A study of the effects of invasive plants on the small mammals and birds of freshwater tidal wetlands

Abstract:

A common assumption is that invasive plant species displace native flora and alter the habitat of native fauna, resulting in a decrease of diversity and species richness. To infer effects of invasive plant species on the freshwater tidal wetland ecosystem, two faunal communities will be studied: small mammals and birds. Diversity and species richness will be compared between habitats with varying percentages of invasive plant species (in some cases the percentage will be zero). I predict that diversity and species richness will be lower in areas with higher percentages of invasive plants. Small mammal trapping and bird point counts will be conducted for three seasons in Tivoli North Bay Marsh and Stockport Marsh, New York. Data will be analyzed using logistical regression. Preliminary data from 1999 and 2000 contradict the common assumption of negative effects caused by invasive plants suggesting that more detailed studies are needed.

Reserve: Hudson River, NY
Fellow: Angela Slagle
Project Title: A remote sensing approach to quantify the benthic environment of the Hudson River Estuary
Abstract:

A suite of geophysical measurements and samples will be exploited to quantitatively evaluate biological activity in the bed of the Hudson River estuary. The goal will be to demonstrate the utility of remote sensing for characterizing and monitoring benthic habitats. Two issues will be addressed: 1) the distribution and abundance of invasive species, and 2) the extent of relic oyster beds including evidence of their present rejuvenation. More than five hundred sediment cores and grab samples from approximately sixty-five miles of the estuary encompassing saline to brackish to freshwater conditions are available. Two Hudson river NERR sites fall within the proposed study area. My project will use an ArcView Geographical Information System (GIS) populated with digital bathymetry, acoustic backscatter, sub-bottom reverberation, riverbed photography, core photographs, sediment grain size, sediment lithology and substrate density, sound-velocity, and magnetic susceptibility. The invasive species is the zebra mussel (Dreissena sp.) that colonizes identifiable substrates of the estuary banks and channel walls and threatens biodiversity. The area and thickness of subsurface oyster beds will be mapped using 3-D software. Rejuvenation will be estimated from three years of successive riverbed sampling and from interviews at marinas that recover moorings. The results of the proposed project should be useful to national estuarine and coastal resource management as an efficient method to access populations, population changes and make decisions relevant to habitat restoration.

Reserve: Jacques Cousteau, NJ
Fellow: Tenley Conway
Project Title: Integrating land use change models and stakeholder interests into a framework for coastal management
Abstract:

The Mullica River and Barnegat Bay Watersheds are two of the least disturbed areas in the heavily urbanized Northeastern United States. However, portions of the region are undergoing rapid land use changes. Although a great deal is already known about past land use changes in the region, comparatively little has been done to project future land use pressures. Work of this sort is essential in developing appropriate management strategies to protect the unique coastal environment. This project will integrate future land use change modeling and stakeholder participation into a planning framework that addresses the management needs of the coastal watersheds.

There are two components to the project. The first will model future land use changes. This will involve the creation of a build-out scenario and an examination of incremental change over time based on various predictive mechanisms. The second component of the project will attempt to facilitate stakeholder participation during the modeling process, through a series of community meetings. Stakeholders will help determine modeling scenarios, and use those scenarios to develop a set of acceptable management strategies. Overall, this project will contribute to the research needs of the Jacques Cousteau National Estuarine Research Reserve and the Barnegat Bay Estuary Program. More importantly it will provide a framework that can be replicated in other coastal areas.

Reserve: Jacques Cousteau, NJ
Fellow: Gregg Sakowicz
Project Title: Essential fish habitat for marsh fishes: Behavioral ecology of larval and juvenile *Fundulus heteroclitus* and *Cyprinodon variegatus*
Abstract:

The proposed study will focus on the behavior and essential habitat of two dominant fish species in East Coast marshes, *Cyprinodon variegatus* (sheepshead minnow) and *Fundulus heteroclitus* (mummichog). Both species are abundant in the Jacques Cousteau National Estuarine Research Reserve (JCNERR) in the Mullica River-Great Bay estuary and most reserves on the East Coast of the United States. The proposed research is based on the premise that it is important to understand the behavior and ecology of the early stages of fish species in order to determine their essential habitat.

The behavioral ecology of early life history stages of both species will be determined based on laboratory and field observations with the JCNERR in the vicinity of the Rutgers University Marine Field Station (RUMFS). Early life stages (larvae and juveniles) will be cultivated in a controlled environment in order to ensure a prolonged study period in the laboratory and then subjected to behavior, stage, and age-specific examination of vertical and horizontal swimming, initiation of feeding, and the effects of density and schooling on activity levels. Results of these experiments will be interpreted in the context of field studies designed to determine microhabitat use patterns on the marsh surface nurseries. Together these observations and experiments will provide useful insight into the habitat use patterns and fish response to salt marsh protection and restoration.

Reserve: Jobos Bay, PR
Fellow: Jennifer Bowen
Project Title: The role of mangrove forests in interpreting land-derived nitrogen loads
Abstract:

Little attention has been paid to the global destruction of mangrove forests, despite their crucial role at the interface between land and sea. These ecosystems help stabilize coastlines and prevent erosion, provide a valuable nursery and feeding ground for commercially important shell and finfish species, and intercept and transform land derived nutrients and pollutants. We propose a two part research plan that aims to demonstrate the role of these coastal ecosystems at attenuating land-derived nitrogen loads. We first intend to apply and verify a series of models that predict nitrogen loads to, and nitrogen concentrations in, the Jobos Bay NERR. The second objective of our research involves the use of stable isotope tracers to quantify the amount of nitrogen that is denitrified and buried as it moves through the estuary.

First, we will modify two models previously developed for temperate ecosystems, and verify their applicability in tropical systems. The first model is designed to predict nitrogen loads entering coastal waters as a result of the land use within the adjoining watershed. This model is designed to estimate estuarine biogeochemical processes, and will provide managers with a means by which to estimate the concentrations of nitrogen that are actually available to primary producers. Both models will be verified against measured estimates of loads and concentrations that were sampled extensively from both ground water and from within the estuary.

After establishing the baseline nitrogen loads and concentrations for the Jobos Bay Reserve, we will use stable isotopes to estimate rates of denitrification and burial within the estuary. We will measure the ^{15}N in the estuarine water, and record changes that occur along a transect from fresh to salt water. We will simultaneously measure the %C, %N, and ^{15}N in the upper 10cm of the sediments along the same transect to estimate the amount of nitrogen that is sequestered within the sediments. Thus, we will be able to quantify the two main pathways by which mangrove forests intercept land-derived nitrogen and help to prevent coastal eutrophication.

Reserve: Kachemak Bay, AK
Fellow: Jennifer Plett
Project Title: Impacts and behaviors of the chiton, *Katharina tunicata*, in the intertidal zone in Kachemak Bay, AK
Abstract:

Grazing is an extremely important factor in structuring communities. One particular grazer, *Katharina tunicata*, is one of the most abundant species in the intertidal community from California to Alaska, but very little is known about its impacts. For example, in Kachemak Bay, Alaska, *Katharina tunicata* can have densities up to 108 individuals per m^2 (Plett, unpublished data). Because of high densities of *K. tunicata* as well as extreme tidal range found in Cook Inlet, the Kachemak Bay National Estuarine Research Reserve is an excellent place to conduct this study. Caging manipulations and mensurative experiments will be done to determine the importance of this abundant chiton to structuring rocky intertidal beaches in Kachemak Bay. Objectives for this study can be divided into two categories. First, I will explore indirect effects of *K. tunicata* on the community structure. And second, I will determine the direct effects of chiton feeding.

Reserve: Narragansett Bay, RI
Fellow: Andrew Altieri
Project Title: Structuring of the estuarine community by the blue mussel, *Mytilus edulis*:, influence of habitat and flow on top-down and bottom-up effects of an abundant benthic suspension feeding bivalve

Abstract:

Physical factors such as flow and habitat can have a strong impact on the dynamics of coastal communities. Understanding their influence is critical to resource management since human development, dredging, and altering of river flow can modify both habitat and flow in estuaries. The blue mussel, *Mytilus edulis*, has been shown to play an important role in structuring biological systems by exerting a strong top-down influence on plankton communities and bottom-up influence on populations of consumers. Moreover, flow and habitat have been shown to mediate the community structuring interactions of *M. edulis*. Preliminary sampling in Narragansett Bay shows that a recent settlement event has boosted *M. edulis* populations to densities exceeding 50,000/m^2. High abundances of *M. edulis* can be found in all of the predominant habitats and flow regimes of Narragansett Bay. It is therefore likely to play an integral role in this system. The purpose of this study is to (1) investigate the role of *M. edulis* in the Narragansett Bay ecosystem and the implications of the recent settlement event, and (2) determine the effects of flow and habitat on *M. edulis* distribution, growth, and community impact. These objectives will be addressed through monitoring and multi-factorial field experiments that will test the separate and interactive effects of flow and habitat type on modifying the top-down and bottom-up impact of *M. edulis* on the Narragansett Bay community. The results of this study will be particularly relevant to resource managers since *M. edulis* has the potential to affect water quality and support both commercially harvested and invasive species. In addition, the results of this study will provide an understanding of how habitat and flow modification can alter community composition and dynamics. Therefore, knowledge gained through this investigation will support NERRS research priorities directed towards sustaining estuarine natural resources and assessing the importance of biodiversity and invasive species in estuarine ecosystems.

Reserve: Narragansett Bay, RI
Fellow: Brian Silliman
Project Title: Relative effects of predation and nitrogen enrichment on the community structure of New England salt marshes
Abstract:

Salt marsh habitats play a number of important roles in coastal ecosystems and economies. In addition to being highly productive, marshes temper coastal flooding, filter terrestrial run-off, act as nurseries for many commercially important species, and reduce erosion. Critical to the long-term preservation of these systems in understanding the factors that influence the success of salt marsh plants, the primary structure-forming organisms in the community. Current theory predicts that bottom-up forces, such as nutrient availability, are the dominant factors regulating marsh grass growth. Recent work in South East marshes, however, has questioned this paradigm and demonstrated that the omnivore-snail, *Littoraria irrorata*, grazes marsh grass at high densities (>100 ind./m^2), resulting in drastic reductions in plant growth. Along the New England and mid-Atlantic coasts, the coffee-bean snail, *Melampus bidentatus*, replaces Littoraria as the dominant gastropod in salt marshes. Densities up to 1500 snails/m^2 are common. Studies have shown that *Melampus* is an omnivore, consuming detritus, diatoms, and live plant material. Despite its ubiquity, great numbers, and apparent potential to affect marsh plant growth, no studies have manipulated *Melampus* densities in the field to assess its community impacts. Therefore, the primary objective of this study is to provide an in-depth understanding of how the grazing activities of *Melampus* affect marsh primary production. In addition, this study will also examine how the effects of *Melampus* grazing vary with marsh eutrophication, a recurring and chronic problem in coastal ecosystems, and how marine predators indirectly control marsh primary production through regulation of snail distribution and abundance. To address these goals, a multi-factorial experimental approach will be used involving manipulation of both snail and predator densities and the concentration of nitrogen in marsh porewater. This research will be focused on marshes within the Narragansett Bay National Estuarine Research Reserve. The results will allow managers to predict potential effects of eutrophication and predator depletion (e.g. green crab population declines) on salt marsh structure and function and to formulate an effective long-term plan to sustain this resource. Because enhancing scientific understanding of estuarine systems and providing information needed by Reserve management decision-makers are central goals of NERRs, this project will address important agency priorities.

Reserve: North Carolina
Fellow: Monica Dozier
Project Title: The role of estuarine reserves in sustaining fisheries: Recruitment, growth, and habitat utilization of red drum in the Rachel Carson Estuarine Reserve, North Carolina

Abstract:

Over harvest coupled with habitat loss and degradation have resulted in dramatic declines in the stocks of many commercially and recreationally important coastal species. A critical element in restoration and management efforts of many of these fisheries is the establishment and continued preservation of reserves and sanctuaries. Particularly for species that suffer low growth and/or high mortality because of a lack of essential habitat or poor quality (i.e. degraded; fragmented) of available habitat, NERR sites could provide a valuable contribution to the sustainability and enhancement of fisheries. In this proposal, I outline a project designed to examine habitat utilization, growth and recruitment of a recreationally and commercially important species, red drum *Sciaenops ocellatus*. As a result of overfishing and degradation of key estuarine habitats, stocks of red drum are currently under severe pressure. Consequently, the identification and preservation of essential habitat for juvenile red drum is of critical importance in the development of effective fisheries management plans.

In this proposal, I examine the role of different habitat types (seagrass, tidal creek, salt marsh edge, subtidal channel, degraded and restored oyster reef) as potential essential fish habitat within the Rachel Carson component of the North Carolina Estuarine Research Reserve for sustaining the red drum fishery. I also examine commercial and recreational harvest of red drum within the reserve. Specifically, the proposal addresses four objectives: 1) quantify type and amount of available bottom habitat types in the Rachel Carson reserve that may serve as essential fish habitats for juvenile and sub-adult red drum; 2) determine habitat use patterns of post-larval, juvenile and sub-adult red drum within the reserve; 3) determine how habitat type mediates growth, predation risk, and foraging success of juvenile red drum; 4) determine commercial and recreational fishing pressure on red drum populations in the reserve.

The proposed work is highly responsive to the National Estuarine Research Reserve System research priorities in that the proposal specifically addresses the issue listed in the RFP of "mechanisms for sustaining resources within estuarine ecosystems" and will also add valuable information on public and commercial use of the habitat to address the priority for "socioeconomic research on estuarine ecosystems." Finally, demonstrating and quantifying the habitat value of reserve sites for fisheries species will provide valuable information to fisheries managers and the public.

Reserve: North Carolina
Fellow: Eileen Vandenburgh
Project Title: An empirical test of the influence of increased spawning stock biomass of *Mercernaria mercenaria* in harvest refugia on spatially explicit recruitment patterns
Abstract:

The three types of marine protected areas (MPAs) are spillover reserves, in which large individuals move from the reserve to surrounding areas; larval export reserves, which export larvae out of the boundaries of the reserve, and bottleneck reserves, through which high concentrations of highly pelagic fishes travel (Nowlis and Roberts, 1998). Although research indicates that fish biomass and abundance are increased within MPAs, we do not know the role that reserves play as a larval sources or sinks in open marine systems, in which recruitment of success is not connected to adult population dynamics because of the effects of larval dispersal (Bertness, 1999).

An experimental approach is now necessary to determine how MPAs affect patterns of recruitment within the seascape encompassing protected areas, for the utility of reserves as spawning banks depends on the transport of eggs, larvae, or juveniles out of the protected area (NRC, 1999). There is critical lack of evidence indication that larvae disperse and enhance recruitment outside the refugia (Dayton et. al., 2000). I propose to investigate the function of MPAs as larval export reserves and their contribution to sustaining fisheries outside the boundaries of the reserves. I plan to compare the spawning stock biomass of hard clams within and outside reserves and then to test whether larval supply and local recruitment of clams is greater within and around refugia than within and around harvested areas. I will also model the spatially explicit patterns of clam recruitment associated with closed and open areas at local and regional scales.

The NERR sites in North Carolina provide a great opportunity to test whether reserves function as larval export reserves. My proposal addresses two of the NERRS research priorities. The first is estuarine ecosystem restoration, for I will investigate if the establishment of harvest refugia for clams will influence the patterns of recruitment within and at increasing distance from the refuge. The second is sustaining estuarine ecosystems, for whether or not these harvest refugia function as seed banks is crucial to know for sustaining both harvested and nearby unharvested areas.

Reserve: North Inlet-Winyah Bay, SC
Fellow: Wesley Johnson
Project Title: Microbial community responses to eutrophication in a southeastern U.S. salt marsh estuary
Abstract:

There is increasing concern about eutrophication of coastal ecosystems, yet its specific effects on food webs and geochemistry are poorly understood. Microorganisms play fundamental roles in both trophic interactions and geochemical cycling; thus understanding the effects of eutrophication on microbial communities is vital to understanding its impact on salt marsh ecosystems. The objectives of this proposal are to elucidate the effects of nutrient loading on microbial communities and identify potential indicator taxa for eutrophication in salt marsh sediments. The impacts on community composition, structure, and function will be tested by manipulating the nutrient inputs (nitrogen (N), phosphorus (P), or (N+P)) in small plots in the mid marsh zone near Goat Island. Pore water samples and sediment cores will be collected monthly from these plots. Concentrations of ammonium, phosphate, nitrate and nitrite, and sulfide will be measured in the pore water, and bulk DNA will be extracted from the sediment. Community profiles will be generated using polymerase change reaction (PCR) followed by denaturing gradient gel electrophoresis (DGGE). Comparisons can then be made between the communities among the plots. Sediment samples will also be used for enzyme activity assays and for determining the relative abundance of specific organisms using fluorescent in situ hybridization with rRNA probes. These data will provide comparisons of changes in composition (PCR/DGGE), structure (in situ hybridization), and function (enzyme activity) resulting from nutrient loading. Understanding the effects of eutrophication on salt marsh microorganisms will help characterize the impacts of nutrient loading system-wide, and may identify sensitive indicator organisms for eutrophication.

Reserve: North Inlet-Winyah Bay, SC
Fellow: Karyn Novakowski
Project Title: Characterization of estuarine channel networks
Abstract:

Tidal creeks and channels dissect the marsh landscape and produce discreet islands with well-defined drainage basin networks. Estuarine habitat structure results from the interactions between salt marshes, channel networks and land use. Therefore, any influence on channel network geometry may influence habitat structure and population density of marsh flora and fauna. Hence, channel network form and processes play an important role in estuarine ecology and stability.

Urban and suburban developments encroaching onto coastal environments may cause alterations to the channel platform. These alterations increase shear stress, perhaps negatively impacting habitat structure, thereby requiring rehabilitation. While marsh habitat creating and rehabilitation efforts are an important part of ecosystem stabilization, the critical question is: Restoration to what? Scaling in estuarine channel network geometry may yield useful indices to describe drainage density equilibrium. It may also elucidate controls on spatial variability of biological processes, which in turn can be used to define restoration goals and objectives.

I propose to use Hack's Law to test for power law scaling in estuarine channel systems. I expect to reveal the utility of exponential scaling may serve as an index needed to assess the large-scale health and stability of estuarine systems. It may also be the basis for channel system design in reconditioned coastal landscapes.

Reserve: Old Woman Creek, OH
Fellow: Scott Lynn
Project Title: Atrazine body burdens and endocrine correlates in channel catfish, *Ictalurus punctatus*, and yellow perch, *Perca flavescens*, from Old Woman Creek Reserve and Lake Erie
Abstract:

Old Woman Creek has significant herbicide contamination from agricultural upland runoff, with atrazine (a chloro-S-triazine herbicide) being one of the most prevalent. Atrazine is the most commonly used herbicide in the U.S. and, like many pollutants, is an endocrine disrupting chemical (EDC). Atrazine is a suspected environmental estrogen, inducing aromatase activity, the rate-limiting enzyme in the conversion of androgens to estrogens. Estrogenic EDCs can have adverse affects on growth, reproduction, development, and osmoregulation by disrupting sexual development, behavior or pituitary function. Yellow perch are an important species both ecologically and economically, especially in Lake Erie with yellow perch adults being piscivorous and top-level predators. Channel catfish are found in relative abundance at OWC and are an excellent species for studying environmental contamination, as they are obligate benthic dwelling fish and moderately tolerant species. My aim is to elucidate the manner in which atrazine influences these animal's endocrine status, and the potential latent effects that result from exposure. As such, I propose to collect channel catfish, *Ictalurus punctatus* and yellow perch, *Perca flavescens*, from OWC and Lake Erie, and to analyze for atrazine body burdens, plasma levels of pituitary hormones, PRL and GH, using immunoassays, as well as tissue-specific mRNA expression levels (PRL,GH, SL, aromatase, - and -ERs, IGF-I and II and PRL-receptor). The significance of this project lies in its focus on agricultural runoff pollution and its possible effects on estuary wildlife. Data generated on hormonal changes in these two distantly related species, in relation to atrazine burden, season, sampling site and sex, will provide valuable baseline data on the endocrine status of these species, but more importantly facilitate more careful analyses into the interaction of EDCs and aquatic vertebrate physiology and potentially provide predictive capabilities useful to monitoring populations where endocrine disruption is suspected. The broader implications could define possible physiological impairments and environmental factors resulting in low population levels and skewed sex ratios in Lake Erie or other estuarine sites.

Reserve: Old Woman Creek, OH
Fellow: In-Young Yeo
Project Title: Development of an environmentally optimized land use model to control non-point source pollution from agricultural areas in the Old Woman Creek and Lake Erie
Abstract:

The proposed study will address the coastal management problems related to non-point source pollution from an agricultural watershed. The impacts of the agricultural land use in the proximate areas of Lake Erie and the Old Woman Creek will be evaluated and the optimal land use management will be proposed to minimize the impacts on water quality. A spatio-temporal model will be developed to describe current environmental conditions and estimate future water quality using long-term monitoring data from the National Estuarine Research Reserve at the Old Woman Creek Reserve in Ohio. Statistical time series analyses will be conducted to understand the temporal behavior and remote sensing techniques will be applied to establish the spatial model of water quality parameters. An environmentally optimized land-use model will be developed to control and manage non-point source pollution in the long run. This model will account for the effects of changing land use management factors via an environmental simulation model and recommend the best management practice and land uses using an optimization technique. The model will simulate the amount of non-point source pollution loading from the agricultural areas and optimally allocate the coastal buffers in critical areas to meet the environmental goal set by the Ohio Lake Erie Commission. This study would make a valuable contribution to Lake Erie and other Great Lake coastal areas, accurately estimating the pollution loadings from agricultural land uses to establish proper regulations and guidelines to control them.

Reserve: Padilla Bay, WA
Fellow: Eric Hellquist
Project Title: Predicting the invasion potential and consequences of the non-indigenous cordgrass, *Spartina anglica*, within Padilla Bay, Washington
Abstract:

The establishment of non-indigenous, invasive taxa in marine and estuarine habitats is a serious threat to the integrity of coastal ecosystems. Species introductions are recognized as a major element of global change and a leading contributor to the loss of native biodiversity world-wide. In Pacific coast estuaries, the non-indigenous invasive cordgrass, *Spartina anglica*, is a significant concern in this regard. First introduced into Washington at Port Susan Bay in 1961, *S. anglica* has expanded to cover approximately 7,000 acres throughout Puget Sound. This cordgrass is a formidable invader due to its ability to "engineer" habitats by converting open tidal mud flats into elevated salt marshes. These alterations make them uninhabitable to eelgrasses and associated wildlife. Padilla Bay National Estuarine Research Reserve (Mt. Vernon, WA) is flanked by populations of *S. anglica* that occupy neighboring estuarine communities to the south. These southern populations are seed sources that annually introduce seeds into Padilla Bay. This continual dispersal requires a vigilant effort to survey and manually remove seedlings before populations become established. We propose research to investigate 1) the dispersal and source(s) of *S. anglica* seeds within Padilla Bay, 2) the physical and biological characteristics that contribute to the pattern of *S. anglica* seedling distribution in Padilla Bay and adjacent estuaries, and 3) the germination and growth potential of *S. anglica* in Padilla Bay as well as in neighboring estuaries that exhibit a gradient of *S. anglica* invasion magnitude. Predicting the invasion potential and consequences of *S. anglica* will contribute to its future management in Padilla Bay. In addition, this study will contribute to our knowledge of the *S. anglica* invasion in Puget Sound as a whole, and will help predict the possible ecological consequences if *S. anglica* is not properly eradicated early in its life history.

Reserve: Padilla Bay, WA
Fellow: Sacha Maxwell
Project Title: Projected sea-level rise and stability of a hydrologically altered Pacific Northwest estuary
Abstract:

Insufficient sedimentation, coupled with high rates of relative sea-level rise (land subsidence plus eustatic sea-level rise), are two important factors contributing to wetland loss in coastal regions around the world. Additionally, the eustatic sea-level (RSLR) is expected to accelerate over the next 100 years. If coastal estuaries are to sustain themselves given rising water levels, they must accrete vertically at a rate that equals RSLR. In Padilla Bay, water flow from the Skagit River has been altered such that the ability of the estuary to remain stable in the face of sea-level rise is in question. The purpose of this study is to (1) determine the rate of sediment accretion and/or subsidence occurring with Padilla Bay, one of the largest contiguous sea grass meadows on the Pacific coast of North America, (2) project the long-term stability of marsh elevation given eustatic sea level rise scenarios, and (3) determine how ground cover type (mud flat, *Zostera marina*, *Zostera japonica*) regulates accretion rate.

A recently developed field technique that uses sediment marker horizons in conjunction with a surface elevation table (SET), an instrument that precisely measures changes in elevation relative to a shallow subsurface datum, has made it possible to partition and measure several of the factors that affect wetland elevation relative to sea-level, including vertical accretion and shallow subsidence. I will use this field technique to determine mean rate of accretion and/or subsidence for the bay. I will use tide gage analysis of recent eustatic sea level rise and future sea-level rise scenarios as defined by the Intergovernmental Panel on Climate Change to test the hypothesis: The rate of accretion in Padilla Bay is sufficient to maintain current surface elevation in the face of sea level rise.

Reserve: Rookery Bay, FL
Fellow: Lauren McDaniel
Project Title: Development of the marine prophage induction assay as an indicator for chemical pollution in Rookery Bay Reserve
Abstract:

The demonstrated relationship between carcinogenicity of a chemical compound in mammals and its tendency to cause prophage induction in bacteria provides a method for biologically based carcinogen screening. Because of the need for this type of screening and the abundance of lysogens in the marine environment, a Marine Prophage Induction Assay (MPIA) has been developed. This assay is patterned after the Microscreen Assay, which is currently in use to screen for bioactive pollutants in freshwater environments.

To develop the assay, marine bacterial isolates were screened for the presence of prophage induction. The isolate designated P94-4S3 (identified as Pseudomonas aeruginosa) was determined to be the best candidate for the MPIA because of its large production of prophage in response to exposure to mutagenic chemicals, rapid growth, easily enumerated virus like particles (VLPs) and a linear response to increasing dose of Mitomycin C. Several experiments have already been performed for the development and optimization of the MPIA procedure. Initial screenings of the MPIA were also performed with selected environmental pollutants.

The next step in development of the MPIA will be testing the assay in the laboratory with pesticide agents and heavy metals found in Rookery Bay to determine the sensitivity of the assay to these agents. The assay will then be tested on environmental water samples. In addition, the assay procedure will be adapted for use with sediment samples. The MPIA will be performed in conjunction with scheduled pesticide application. Toxicological evaluation of the samples will be performed concurrently as well as performing the assay on uncontaminated environmental samples as controls.

Reserve: Rookery Bay, FL
Fellow: Kathy Worley
Project Title: Determination of underlying causes of mangrove die-offs located adjacent to encroaching development
Abstract:

Mangroves are facultative halophytes that are uniquely adapted to survive in anoxic, waterlogged saline soils in tidal areas of tropical and subtropical environments. Mangroves are an important part of South Florida's shoreline ecosystems. Not only do they provide habitat for a variety of organisms, but contribute significantly to the overall nutrient cycle in upper and lower intertidal zones. Mangroves are an intrinsic part of the southern Florida's heritage and continuation of viable coastal ecosystems. Human activities have negatively impacted the vitality of mangrove ecosystems. These impacts are the result of land clearing and subsequent erosion through hydrological modifications that occur when an area is developed. In some mangrove systems, this results in large-scale die offs.

It is hypothesized that water levels and retention periods are significantly higher and the elevation is lower in mangrove die-off areas versus tidally directed water levels in live areas that have lower retention periods and slightly higher elevation. Additionally, it is suspected that soil redox levels are lower in die-off areas causing additional stress to mangrove seedlings that might try to become reestablished. To address these issues, this proposal describes a field study designed to evaluate hydrologic regimes, attain a basic understanding of soil conditions and evaluate mangrove recovery within two separate die-off areas. This project will investigate: surface and ground water levels and retention periods, surface elevation, soil redox, soil salinity, primary nutrient substrate composition and vegetation characterization.

This project is designed to provide information on suspected causes of mangrove die-offs in areas that have been hydrologically altered and to collect baseline data on substrate conditions. Naples, Florida is one of the fastest growing areas in the country. To effectively manage and sustain coastal resources it is vital to know how human activities impact the estuary and how mangrove ecosystems react to the impacts of an ever-growing population and booming development. Once the underlying causes and effects have been determined, restoration initiatives will have a greater chance at success.

Reserve: Sapelo Island, GA
Fellow: Christina Richards
Project Title: Genetic and physiological variation of three salt marsh plants at the Sapelo Island NERR
Abstract:

Salt marsh habitats are important for health of fisheries, protection against storm damage and potential filters against toxins entering marine and ground water systems which has encouraged many studies of salt marsh community ecology. However, we still lack an understanding of how plants respond morphologically and physiologically to these gradients and the genetic basis of their responses. Understanding the ability of plant communities to respond to their environment will aid the NERRS in accomplishing their objective of protecting biodiversity, sustaining resources and restoring ecosystems.

Using a combination of field sampling, physiological measurements, genetic analyses, and field and greenhouse experiments, this study will reveal physiological and genetic patterns of response to microscale variation in environment. Field experiments will be carried out on Sapelo Island NERR, an ideal setting to document natural salt marsh ecology and evolution. The Sapelo NERR preserves some of the last unaltered salt marshes along the Atlantic coast serving as a role model for natural levels of biodiversity and setting a standard for restoration.

Identifying local adaptation to microhabitats is important for marsh conservation because the potential for adaptation to change is directly related to the amount of variability present in the population. Maintaining genetic diversity in effect preserves the future options to resist and recover from changes in environment. Similarly, restoring a destroyed marsh habitat requires understanding that certain genotypes are more adapted to survive under certain conditions. These studies will provide critical information on the genetic structure of marsh plant populations at several spatial scales. This information for successfully maintaining pristine marshes and restoring damaged marshes in changing environments.

Reserve: Sapelo Island, GA
Fellow: Merrilee Thoresen
Project Title: Temporal and spatial variation in seston available to oysters and the contribution of benthic diatoms to their diet in the Duplin River, Georgia
Abstract:

The American oyster, *Crassostrea virginica*, is the dominant suspension-feeding bivalve in many estuaries. Populations living in natural environments eat a mixture of phytoplankton, detritus, and benthic microalgae, and must adapt to variation in food quality and quantity over both temporal and spatial scales. In shallow coastal waters where climactic or tidal conditions favor resuspension, benthic algae can greatly augment algal biomass and productivity in the water column. Although benthic diatoms have been posited to be an important food source for bivalves, this has never been directly quantified. In the proposed work, we will examine the quality of the seston available to oysters in the Duplin River Estuary, Georgia, to determine the contribution of benthic diatoms over temporal (tidal, lunar, seasonal) and spatial (creek bank, mudflat, different tidal reaches) scales. For an accurate assessment of the seston available to oysters, water will be sampled from above the reefs. The concentration of total suspended solids, particulate organic matter (POM), particulate organic carbon (POC), particulate organic nitrogen (PON), chlorophyll a, and phaeopigment will be measured in water samples as well as in surface (top 5 mm) sediment samples collected from mudflats adjacent to oyster reefs. In order to examine the contribution of benthic diatoms to the diet of oysters, we will enumerate both planktonic and benthic forms (identified to genus) found in the seston, the sediment, and the gut contents of oysters. Finally, stable isotopes on selected water, sediment, and oyster samples will be used to provide further information on available food resources and the diet of the oysters. Using these data we will be able to better evaluate how estuarine waters provide food for bivalve suspension feeders and how these resources vary throughout the year and among different locations in a tidal inlet. If benthic diatoms are quantitatively important for oysters, then managers interested in monitoring these populations and their food resources will have to consider not only phytoplankton, but benthic algal biomass as well.

Reserve: South Slough, OR
Fellow: Michael Berger
Project Title: Recruitment dynamics of *Balanomorph* barnacles along an estuarine gradient
Abstract:

The mechanisms that drive marine invertebrate community structure are a dynamic process involving both pre-metamorphic (larval supply) and post-metamorphic (juvenile performance) factors. Preliminary data indicates that barnacle species within the South Slough NERR have defined ranges with small overlap. *Balanus crenatus* (indigenous species) occurs in the lower estuary, while *Balanus improvisus* (introduced species) is abundant in the upper estuary. I propose to study the processes controlling the observed barnacle distributions. Initially, I will quantify the adult distribution within the South Slough estuary. Larval abundance from plankton net tows and recruitment on slate panels will address the issue of larval supply. To address post-metamorphic factors, naturally settling and lab reared juveniles will be out planted in the field using a reciprocal design. Juvenile stress, as a function of location in the estuary will be determined using the expression of stress proteins (hsp70), as a measure of stress. These proposed experiments would monitor barnacle larvae entering or remaining and then potentially settling in the estuary. Understanding the role of recruitment dynamics is necessary to determine the processes that establish and maintain invertebrate communities (e.g. biodiversity) in estuaries. Understanding the processes that control the distribution of an introduced species, such as *B. improvisus*, has significant importance in determining the introduction and spread of invasive species.

Reserve: South Slough, OR
Fellow: Jessica Miller
Project Title: Patterns of transport, delivery, and habitat use in coastal fishes
Abstract:

The importance of estuaries as nursery areas is well established for many species of coastal fishes (Bottom et. al. 1988; Pearcy and Myers 1974). Mechanisms of estuarine delivery, however, and the extent of larval transport and exchange among estuaries along the NE Pacific are poorly understood. Furthermore, habitat specific patterns of estuarine use are not known for most species. The proposed research will: 1) use daily light trap samples to document the abundance and distribution of marine fish larvae and juveniles in lower Coos Bay and the South Slough NERR; 2) identify probable mechanisms of estuarine delivery, such as wind-driven downwelling, with time series analysis; 3) test the potential of otolith elemental signatures to estimate the extent of larval exchange of the sharpnose sculpin, *Clinocottus acuticeps*, among estuaries; and 4) conduct laboratory experiments with artificial seagrass to determine if foraging success of bay pipefish, *Syngnathus leptorhynchus*, and staghorn sculpin, *Letocottus armatus*, is altered by structural differences between a native, *Zostera marina*, and an introduced, *Z. japonica*, eelgrass. This proposal directly addresses two of the research areas identified: 1) mechanisms for sustaining resources within estuarine ecosystems. The information generated will be useful for determination of habitat requirements of coastal fishes and the assessment of habitat loss, alteration and restoration. A greater understanding of larval exchange among coastal regions will aid the establishment of future marine reserves.

Reserve: Tijuana River, CA
Fellow: Milan Mitrovich
Project Title: Spatial and food web ecology of a sensitive snake species, *Masticophis flagelhum fulginosus*, and its response to human habitat disturbance
Abstract:

The proposed research will provide management with critical information concerning: 1) the preferred habitat; 2) response to human disturbance; and 3) the interspecific ecology of a rare and sensitive subspecies of snake, the Baja California coachwhip, *Masticophis flagellum fuliginosus*. I will radio-track 30 individual Baja California coachwhips within the Tijuana River National Estuarine Research Reserve (TRNERR) over the next 3 years. Over this same period I will also perform a mark-recapture study of the snake in four different habitat types found within the TRNERR (upland marsh, coastal dunes, coastal sage scrub (CSS), and degraded habitat). Tracking radio-tagged snakes will lead to individual movement/activity data that will describe areas within the four different habitat types that individuals prefer, as well as identify how frequently individuals move between habitat types. Mark-recapture studies allow the comparison of growth rates, fecundity, size structure, and population densities across the four habitat types. The impacts of human disturbance in the form of roads, degraded habitat, edge effect, and human traffic, will be evaluated based on the movement response and incidence of mortality of coachwhips as they move through or come into contact with these areas. The interspecific relationships between coachwhips and their predators/prey represent natural factors that impact the viability of Baja California coachwhips within the TRNERR. I will use radiotelemetry, mark-recapture techniques, and models of coachwhip snakes to assess the significance of raptor predation on coachwhips and the significance of coachwhip predation on sensitive nesting shorebird species.

Reserve: Tijuana River, CA
Fellow: Joanna York
Project Title: HPLC and stable isotopic measurements of nitrogen uptake by phytoplankton in the Tijuana estuary
Abstract:

The Tijuana Estuary offers the opportunity to study phytoplankton dynamics in a setting that varies in degree of nutrient loading as well as seasonally in delivery of freshwater and sediments. Three-quarters of its watershed are in Mexico and it is occasionally subject to raw sewage inputs. The watershed includes heavily urbanized and agricultural areas.

Nitrogen entering the estuary from the watershed has a distinct isotopic signature, depending on its source. Phytoplankton isotopic signatures are representative of their sources. For example, phytoplankton using DIN derived from wastewater acquires a heavy isotopic signature. Thus, it is possible to use an isotopic approach to determine the source of nitrogen assimilated by phytoplankton. An isotopic approach also allows determination of the different forms of nitrogen use, assuming that their signatures differ. There has been debate as to whether phytoplankton prefer NH^4 or NO^3. I propose to determine the preferred from of nitrogen, as well as the source of nitrogen, used by phytoplankton by use of stable isotopes.

By studying these questions in the different arms of the estuary and during different seasons, I will be able to determine how these processes are affected by such factors as degree of urbanization, amount of freshwater input, and different sediment load.

The work described in this proposal complements previous work in the Tijuana Estuary, providing information about sources and forms of nitrogen in the estuary. The results will be compared to results from Waquoit Bay, MA to address whether the methods are broadly applicable as well as tell us much about whether inter NERR comparisons usefully contribute to understanding applied and basic issues of estuarine sciences. The results will have general application, as well as contribute to management plans at the Tijuana River NERR.

Reserve: Waquoit Bay, MA
Fellow: Kevin Kroeger
Project Title: The influence of land use within the Waquoit Bay watershed on the quantity and lability of the organic nitrogen to the estuaries
Abstract:

The objective of the proposed research is to define how the quantity and biological availability of terrigenous dissolved organic nitrogen (DON), transported to estuaries by groundwater flow, are influenced by the land use mosaic on watersheds. The results will be used to develop the ability to estimate the magnitude and biological availability of DON loads based on land use within watersheds. I am concerned with DON in this proposal because: 1) DON is almost always the major form of N in coastal groundwater and estuarine water, 2) some substantial portion of DON is labile and contributes to eutrophication, and 3) to the extent that DON is labile, protocols currently used by municipal, state and federal agencies to estimate N loads to coastal waters either underestimate N loads if they do not consider the contribution of available DON, or overestimate N loads if they calculate total N inputs.

To test whether changes from forested to urbanized land use on coastal watersheds alter sources and amounts of DON transported by groundwater to estuaries, I will use differences in the degree of urbanization on the watersheds of three of the subestuaries of Waquoit Bay as a regional-scale experiment in terrigenous N loading. I will collect samples of the groundwater about to flow into the estuaries, measure the concentration of "delta" ^{15}N of the DON in those samples, calculate DON loading rates, and relate those variables to land use within the contributing watersheds. I expect that the forest-derived DON will have a relatively constant "delta" ^{15}N signature from one subestuary to the next, and that the addition of wastewater DON with urbanization will produce an increase in the ^{15}N content of the bulk material. To test whether the wastewater derived DON is preferentially remineralized and whether the total lability of the groundwater DON increases with increasing urbanization, I will perform incubation experiments to measure the fraction of DON in groundwater that is available to estuarine microbes. I will measure "delta" ^{15}N of the DON both before and after incubation to get estimates of the signatures of the labile and refractory fractions of the material. I expect that the labile fraction of the DON will increase with increasing urbanization on the watershed. In addition, I anticipate that wastewater-derived DON will have a heavier isotopic signature and that it will be remineralized preferentially during incubation. By relating DON lability to both the degree of urbanization on watersheds and to the stable isotope signature of the starting material I will have two tests of my hypothesis.

This project has great significance at both the local and global scale. In spite of the large DON inputs to estuaries, no protocols currently exist for relating land use on watersheds to the quantity or quality of DON loaded to estuaries through groundwater. The results of this work will be incorporated into two nitrogen loading models: 1) the Waquoit Bay Nitrogen Loading Model which is designed for management of individual water bodies, and 2) Sybil Seitzinger's protocol for estimating global export of biologically available nitrogen from land to sea. These models will provide dramatically better estimates of effective nitrogen loads, and will improve management of coastal systems. In addition, this research will improve our understanding of the biogeochemistry of organic matter cycling in coastal systems.

Reserve: Waquoit Bay, MA
Fellow: Gabrielle Tomasky
Project Title: Do nitrogen loads and water residence times control species composition and taxonomic structure of phytoplankton on Waquoit Bay, MA?
Abstract:

Controls of estuarine phytoplankton species composition and abundance are poorly understood, but nitrogen loading rate and water residence time must be included as two important driving variables. For example, there is evidence that estuarine phytoplankton readily respond to increased nutrient supply by increases in biomass and production, although there is less information about whether enriched conditions significantly affect species composition of phytoplankton.

For phytoplankton to respond to nutrient loading from watersheds, requires that the assemblage of species present have sufficient time to grow to the level allowed by the supply of limiting nutrients. Because different phytoplankton taxa have characteristic ranges of division rates, the amount and composition of phytoplankton assemblages could therefore depend on water residence time.

The objective of this study is to investigate the role of nitrogen loading rate and water residence time as controls of species composition and abundance of phytoplankton in estuaries of Cape Cod that differ in land-derived nitrogen loads and water residence time. I predict the following in water bodies in which water residence time is shorter: 1) the tightness of the bottom-up coupling between land-derived nutrient load and phytoplankton response will be more evident (the relationship of biomass, production, and composition of phytoplankton will be more closely related to (N, P, Si) load; and 2) the assemblage of phytoplankton species found in fresh-to-brackish reaches of estuaries will tend to be dominated by taxonomic groups characterized by faster division rates.

To test these predictions phytoplankton in four estuarine systems on Cape Cod, MA will be compared. Phytoplankton samples will be obtained for taxonomic identification along a fresh to saline gradient at three stations in each of the study estuaries. To evaluate the relative stocks and production by the different size groups, chlorophyll concentrations (by standard techniques) and production (using light and dark bottles and oxygen electrodes) will be measured throughout the year.

The results of this study will have evident management implications and will furnish information on: 1) the effects of water residence times and non-point source pollution (in the form of land-derived N loading) on the phytoplankton of these water bodies, which provide the food supply for commercially important stocks within estuarine ecosystems; and 2) add insight to the functioning of estuarine ecosystems by assessing the controls of species composition of phytoplankton, which are the base of the estuarine food web.

Reserve: Weeks Bay, AL
Fellow: Adrienne Dunsmuir
Project Title: Effects of anthropogenic eutrophication on the magnitude and trophic fate of microphytobenthic production in estuaries
Abstract:

Microphytobenthic communities are an integral part of estuarine ecosystems, playing an important role in sediment stabilization, biochemical processes and primary production. The trophic importance of microphytobenthos in estuarine food webs depends on the fate of its production (i.e. the routes microphytobenthic production can follow, for instance herbivory, burial and export). Yet, very few studies have examined the fate of microphytobenthic production. As a consequence, the trophic role of microphytobenthos in estuaries is poorly known. In addition, little is known about how human-induced eutrophication affects this role, although this is an important piece of information to understand the impacts of eutrophication on the ecology of estuaries.

This study aims at examining the magnitude and fate of microphytobenthic production in three sub-estuaries of Mobile Bay, AL, subject to contrasting levels of eutrophication. The study sites will be located at the mouths of Weeks Bay, Dog River and Fowl River. Microphytobenthic chlorophyll concentrations will be measured in sediment cores 2.5 cm in diameter. Primary production will be estimated by quantifying the uptake of ^{14}C by core samples incubated with in situ conditions. Herbivory and export will be determined using cages deployed in the field. Burial will be estimated as the increment in phaeophytins (chlorophyll degradation production) with increasing sediment age. Moreover, to better understand the differences observed in the magnitude and fate of microphytobenthic production, I will also measure ammonium, nitrate, nitrite, and phosphate, and particulate C/N ratio in the sediment; and water column chlorophyll, total solids in suspension and light extinction.

This research will substantially contribute to the understanding of the ecology of Weeks Bay because microphytobenthos is the most important primary producer in the Bay and, yet, little is known about the magnitude and fate of its production. Moreover, this project will compare estuaries that have differing levels of eutrophication, thus presenting information that will be useful for the management of estuaries under increasing levels of eutrophication. This study, therefore, falls well within the NERRS research priority areas of "the effects of non-point source pollution on estuarine ecosystems" and "mechanisms for sustaining resources within estuarine ecosystems."

Reserve: Weeks Bay, AL
Fellow: Carrie Yoder
Project Title: Potential effects of global climate change on the wetland to upland transition zone
Abstract:

The global climate is changing and is affecting numerous atmospheric and oceanic processes including sea level rise and the frequency, intensity, and timing of both thunderstorms and tropical storms. Coastal plant community composition, biodiversity and distribution may be altered as a result of environmental tolerance limits and altered competitive abilities under new environmental conditions. Changes in transition zones are indicators of larger-scale changes, and therefore the wetland to upland transition zones of Weeks Bay NERR are ideal study sites.

I will survey transects from the shoreline through the upland communities and conduct three experimental manipulations to test the hypothesis that biodiversity and productivity will be altered under simulated conditions of global climate change. The transect survey will systematically evaluate abiotic and biotic variables in the coastal communities to determine the primary variables that influence species distribution relative to the shoreline. To investigate the effects of hurricane disturbance on species composition and growth, I will simulate hurricane disturbance of wrack deposition, salinization by storm surge, and gap formation. A transplant experiment will be used to determine the effect of altered hydrology for coastal plant species by transplanting transition zone species to the lower marsh. Previous studies in both wetland and upland communities have demonstrated non-linear additive effects of multiple disturbances, and therefore I will test the combined effects of sea level rise and hurricane disturbance in an interaction study.

Baseline data will provide an understanding of the distribution of macrophyte communities relative to the shore. Experimental results will be incorporated into a geospatial model of the wetland area and predictions of sea level rise to provide evaluative criteria useful in identifying critical habitat areas that will be impacted by environmental change. Results will provide information about how global climate change will affect coastal community diversity to enhance future estuarine conservation management under conditions of global climate change.

Reserve: Wells, ME
Fellow: Alyson Eberhardt
Project Title: Evaluation of culvert impacts and tidal restoration on fish communities in New England salt marshes
Abstract:

With much of the salt marsh habitat that historically lined the New England coastline altered or destroyed, efforts have begun to restore the tidal regime and functional values to the remaining systems. Many of the benefits of tidal restoration projects are fairly well known (e.g. changes to vegetation structure), but higher order functions of use and productivity by secondary consumers are not yet understood. It is well documented that salt marshes serve as important habitats for feeding, spawning, and refuge for many species of fish. However, the effects of tidal restrictions on fish use of New England salt marshes are poorly known. This study will examine tidally restricted, tidally restored, and reference salt marsh habitats to determine the effects of tidal restriction and culvert size on fish passage, populations, and productivity. It will also examine the benefits of tidal restoration for estuarine fish communities.

Fish will be captured via unbaited minnow traps placed along the creek edges of restricted, restored and reference salt marsh areas. Minnow traps have been proven to be a successful method for mark recapture studies due to a higher recapture rate than other methods. Captured fish will be identified, measured for length and biomass, and marked via subcutaneous injection of acrylic paint. Color and mark location will vary between sites, location upstream and downstream, sampling date, and fish class size. Fish will then be returned to the area in which they were caught. Sampling will also be conducted with fyke nets to set up as weirs in order to estimate fish populations of all important species. Results will help us understand how culverts affect the movement of fish and provide quantitative information on energy flow up the trophic structure of coastal systems when tides are restored to salt marshes.

Reserve: Wells, ME
Fellow: Caitlin Mullan
Project Title: Understanding shifting wetland community organization and diversity along salinity gradients: The roles of physical stress and competition
Abstract:

Understanding the mechanisms that generate species distribution patterns in natural communities is critical to comprehending and preserving landscape community structure and to predicting the effects of anthropogenic change to the environment. The proposed research will address processes that structure two important community patterns in coastal marshes: 1) zonation across estuarine salinity gradients and 2) the maintenance of biodiversity in the poorly studied, fresh water reaches of coastal marshes. In estuarine marshes, plant community composition changes dramatically from the coastal river mouth to the head of tide. Salt marshes are characterized by distinct elevational zones of dominant grasses. Fresh tidal marshes, on the other hand, contain a mix of background grasses with annual and perennial seed plants interspersed throughout. As salinity decreases up the estuary, not only is there a significant shift in dominant vegetation type, but there is also a remarkable increase in species richness. How biotic and abiotic factors interact to generate the dramatic changes in community structure along the estuarine gradient has never been addressed.

The primary objectives of this proposal are to tease apart the mechanisms that lead to the striking spatial segregation of plant species across estuarine salinity gradients and explore the biotic interactions that potentially lead to the increased biodiversity in the fresh tidal marsh through manipulative field experiments. This research will be focused on marshes within the Wells NERR and neighboring Southern Maine marshes. Results from this study will provide a mechanistic understanding of the organization of plant communities across the full estuarine gradient. These results are invaluable for coastal marsh conservation and management, particularly in predicting the effects of altered hydrologic regimes, eutrophication, and invasive species on estuarine marshes.